Industrial Ecology: Design with Nature

SESHA/DTSC

Joint Pollution Prevention Mini-Conference

5 November 2003

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Natural Logic, Inc.

Natural Logic

Building profit and competitive advantage through exceptional environmental performance

Strategy:

Value generation

Strategic Sustainability™ Consulting
Strategic Supply Chain Partnerships™
Marketing and product development
CSR reporting as strategic business tool
Sustainable economic development
Life cycle thinking

Design:

Collaborative Innovation

Integrative design process / charrettes
Green / High performance buildings
LEED training and process management
Green materials research / specification
Permaculture systems: design with nature
Building / Site / Natural system integration

Tools:

Metrics, Dashboards, Reporting

Business Metabolics™ benchmarking software
Key Performance Indicators development
CSR Reporting Power Tools
EcoAudit Toolkit
EQE Checklist

Operations:

Advanced resource productivity

Integrated EcoAudits: process efficiency
Environmental Management Systems
Evaluation & implementation
Green building operation protocols
Profit Discovery processes

Industrial Ecology: What it is, what it isn't, and why

- The industrial ecology concept has deep practical and intellectual roots, stretching far earlier than the oft-cited Kalundborg example.
- Considerable promise for improving economic performance while reducing industry's environmental footprint.
- Considerable challenges -- technical, entrepreneurial, some of them perhaps intrinsic to the current Eco-Industrial Development model itself -- to realizing that promise.
- Eco-Industrial Development -- the application of industrial ecology principles to industrial development and regional economic development
- Idea has captured the imagination of countless analysts and some 60 North American communities.

Context

Something has shifted

- **Sustainability:**
  Moving from gleam to mainstream
- **More significant than the shift from "pollution prevention" to "pollution control"**
- **Transforming "environment" from a financial burden to a source of strategic business advantage**
    - Process efficiency
    - Design revolution
- **Transforming role of business**

Why should we care?

- Resource depletion
- Pollution, health, productivity
- Life support systems: Air / Water / Food / Biodiversity / Climate
- Balance of payments
- License to operate
- Competition
- Social equity & social stability

Massive economic impacts

- Money down the drain
- Profit margins squeezed
  - uncontrolled yet avoidable resource costs
  - inefficient production processes
- Risk management diverts critical resources
- High cost & value
  - customer and employee loyalty
  - brand erosion

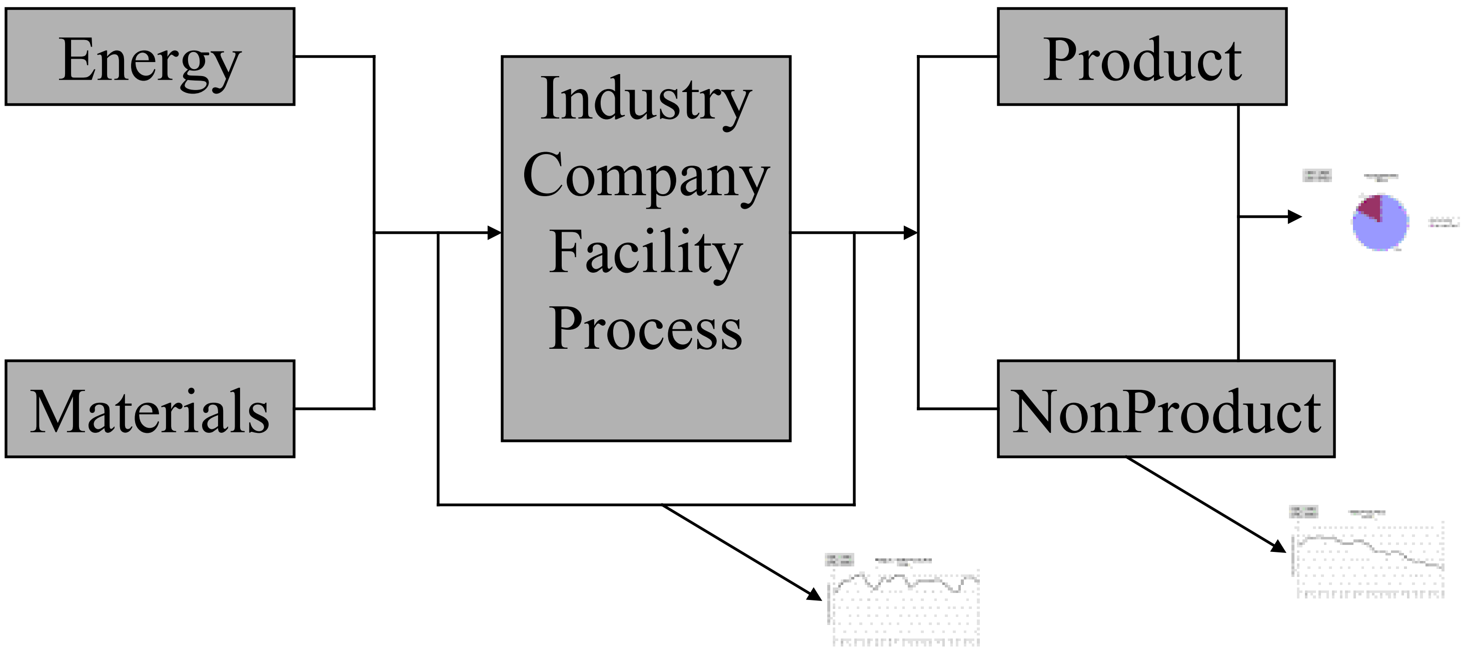
Energy “down the drain”

- US manufacturing
  - $64 billion on fuels and electric energy
- US trade
  - 1999 energy imports $44.6 billion
  - 1999 trade deficit $218.2 billion
- US energy budget
  - $200 billion/year national savings
    if we just match Japan

Materials “down the drain”

- **US manufacturing**
  - **$1.9 trillion on materials**
- **“Waste” treatment & remediation:**
  - **$81.9 billion annual expenditures**
- **Pollution abatement:**
  - **$8.4 billion capital investment for manufacturers**
    - **(7.5% of total capital investment)**
  - **$19.2 billion operating costs**
- **“Total Cost of Waste”** (Steven Rice)
  - **4-10 times direct (disposal) costs**

Only two things...



“Waste”? No such thing!

- **Contextual - like weeds - yet significant**
- **No “waste” in nature**
- **“Non-Product Output” adds no value to a company’s customers *or* shareholders**
- **The U.S. economy’s physical output?**
  - **94% “waste”**
- **Accounting systems miss full costs**

Enter: Industrial Ecology

Industrial Ecology: Design with Nature

- **Nature's ecosystems have more than 3.5 billion years of experience evolving efficient, complex, adaptive, resilient systems.**
- **Why should companies reinvent the wheel, when the R&D has already been done?**

- Gil Friend, 1991

History

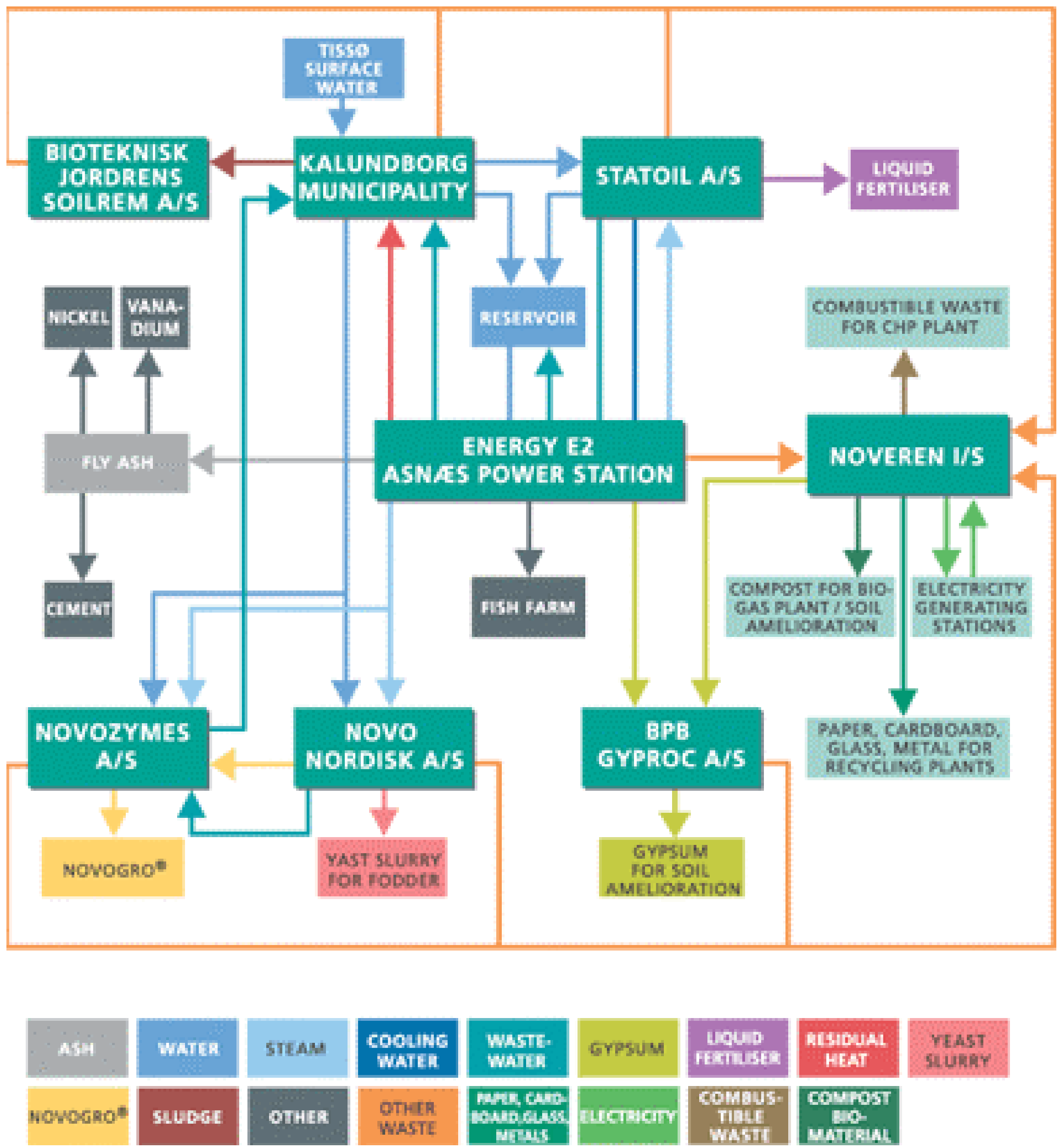
- Benyus, Biomimicry, 1997
- Friend, EcoMimesis 1996
  - http://www.natlogic.com/resources/nbl/v05/n04.html
- Tibbs, Industrial Ecology 1992
- Various, sustainable agriculture 1970s-80s
- McHarg, Design with Nature 1972
- Van Dresser, Landscape for Humans 1940s
- Howard, An Agricultural Testament 1890s
- Indigenous agriculture

Trajectory

- **Kalundborg**
- **EcoIndustrial Parks**
- **EcoIndustrial Estates**
- **EcoIndustrial Networks**
- **Zero Waste strategies**

Kalundborg

- **Collaboration between five industrial businesses for mutual economic and environmental benefit**
  - Power plant
  - Fish farm
  - Pharmaceutical company
  - Agricultural farms
- **Projects**
  - recycling water:
  - exchanging energy at different levels: waste steam, district heat
  - waste products to inputs (e.g. sludge to fertilizer)



TISSØ SURFACE WATER
BIOTEKNISK JORDRENS SOILREM A/S
KALUNDBORG MUNICIPALITY
STATOIL A/S
LIQUID FERTILISER
NICKEL
VANA-DIUM
RESERVOIR
COMBUSTIBLE WASTE FOR CHP PLANT
FLY ASH
ENERGY E2 ASNÆS POWER STATION
NOVEREN I/S
CEMENT
FISH FARM
COMPOST FOR BIO-GAS PLANT / SOIL AMELIORATION
ELECTRICITY GENERATING STATIONS
NOVOZYMES A/S
NOVO NORDISK A/S
BPB GYPROC A/S
PAPER, CARDBOARD, GLASS, METAL FOR RECYCLING PLANTS
NOVOGRO®
YAST SLURRY FOR FODDER
GYPSUM FOR SOIL AMELIORATION
ASH
WATER
STEAM
COOLING WATER
WASTE-WATER
GYPSUM
LIQUID FERTILISER
RESIDUAL HEAT
YEAST SLURRY
NOVOGRO®
SLUDGE
OTHER
OTHER WASTE
PAPER, CARD-BOARD,GLASS, METALS
ELECTRICITY
COMBUS-TIBLE WASTE
COMPOST BIO-MATERIAL

Zero waste

- **Dupont reduced pollutants 80% in five years.**
- **"It was actually easier to motivate the 80 top managers to commit to zero emissions than it was five years ago to motivate them to commit to reduce 80% waste."**
  - Edward Woolard, Chairman & CEO

Principles
(or, The Story of 0)

Industrial Ecosystems:
Modeling on natural ecosystems

- **No waste (the output of one process becomes the input for another);**
- **Concentrated toxins are not stored, but synthesized as needed;**
- **"Elegant" cycles of materials and energy weave among the companies;**
- **Systems are dynamic, and information driven;**
- **Independent participants in coordinated action.**

– Hardin Tibbs

Program for Industrial Ecology

- **Creation of industrial ecosystems**
- **Balancing industrial output to natural ecosystem capacity**
- **Dematerialization**
- **Improving metabolic pathways**
- **Systemic patterns of energy use**
- **Policy alignment with long-term perspective of industrial system evolution**

– Hardin Tibbs

Design Principles

- **Understand ecosystem dynamics, and the competitive pressure for optimal efficiency of both organism and ecosystem**
- **Model metabolism—flows of energy and cycles of materials**
- **Watch boundaries and interactions**
- **Do more with less**
- **Reduce dissipative uses**
- **Stack functions—multi-purpose processes and components**
- **Shift from capital-energy to income-energy**

– Hardin Tibbs

Design Principles

- **Long term optimization, rather than short-term maximization**
- **Maintaining and enhancing regenerative capacity**
- **Diversified system**
  - components linked in complementary functioning (to minimize outside inputs/exports)
  - diversity of many kinds: species, spatial, structural, temporal, and *trophic* (Hollings)
- **Multi-functional biological components minimze need for industrial inputs**
- **Turn "waste" into nutrients/feedstocks**
- **Careful attention to rates and cycles**
- **Match flows to needs**

  – [Friend 1978, Hodges 1978]

Design Principles

- **Diverse, modular production units**
- **Renewable energy sources**
- **Variety of raw materials, multiple sources**
- **Leverage of Aggregate Efficiencies**
- **Optimal rates**
- **Synergism and Symbiosis**
  - Holmes/Todd 1995

Design Principles

- **Current solar income**
- **Waste equals food**
- **Respect diversity**
    – Bill McDonough

Design Principles: Resilience criteria

- dispersion
- numerical redundancy
- functional redundancy
- optional interconnection
- flexibility
- modularity
- internal buffering
- technical simplicity and forgivingness
- easily reproducable

– Hollings 1978

Design Principles

- **Material flows**
  - Close material loops
  - Shorten loops
  - Use "waste" streams
  - Rich interconnections
- **Minimize:**
  - throughput
  - extraction of virgin materials
  - non-renewable energy
  - adverse environment impacts
  - persistent bioaccumulative toxics (PBTs)
  - human health effects
  - transport distances

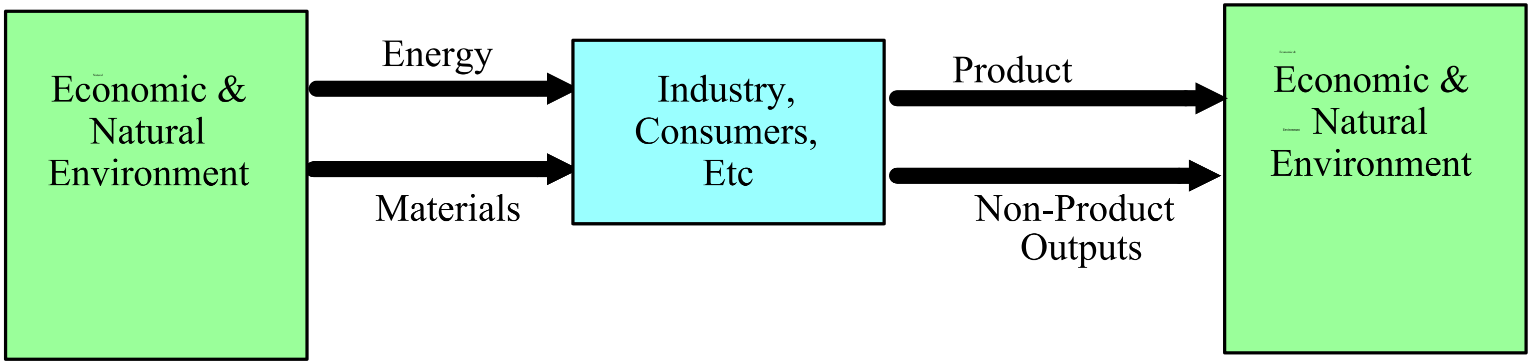
Design Principles

- **Products**
  - Long lasting products
  - More service, less product
- **Maximize**
  - Product life
  - Diversity and interconnection
  - Closed material loops
  - Resource Efficiency
  - Added value

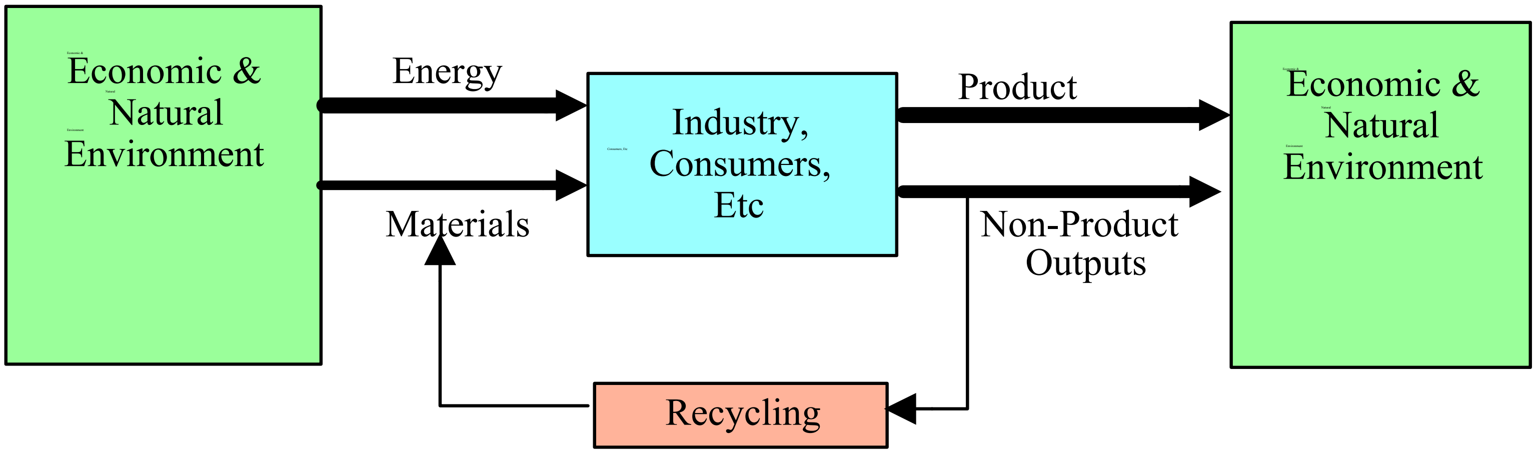
Design principles & Key Indicators

- **Low throughput**
- **Minimize extraction**
- **Minimize energy use**
- **Close - and shorten - material loops**
- **Rich interconnections**
- **Reduce**
  - adverse effects to natural environment
  - non-renewable energy
  - human health effects
- **Long lasting products**

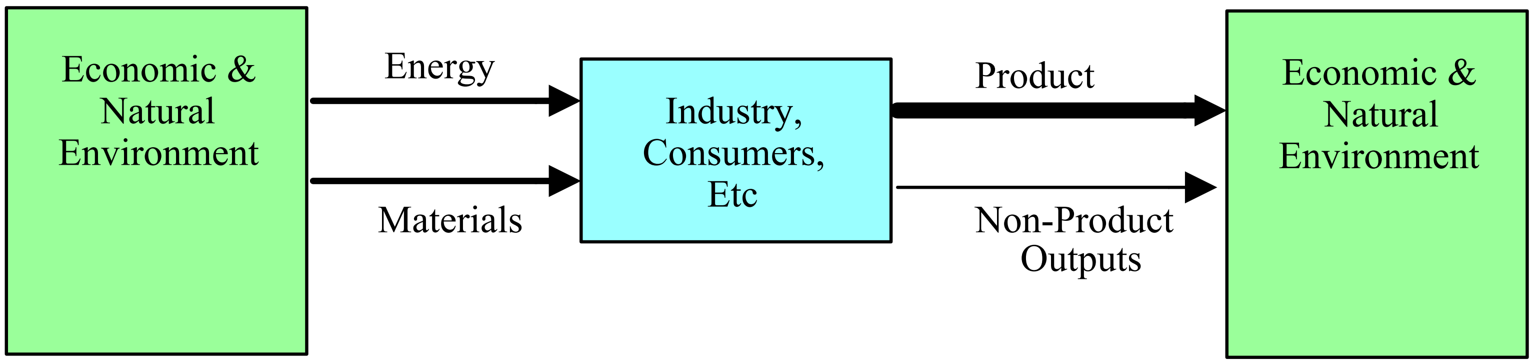
Metabolic Efficiency Strategies



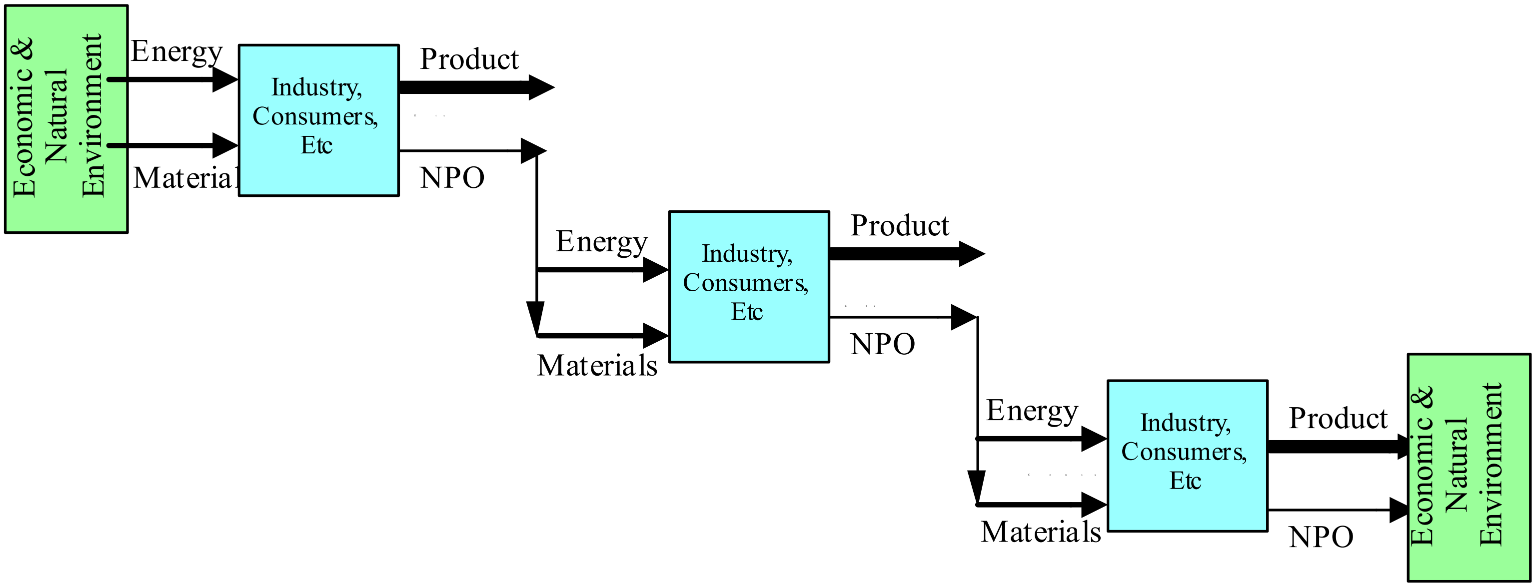
Metabolic Efficiency Strategies: Recycling?



Metabolic Efficiency Strategies: Reduce NPO



Metabolic Efficiency Strategies: Cascading



Metabolic Efficiency Strategies: Parameters

- **Networks**
- **Closed "technical" cycles**
- **Renewables**

System Conditions for Sustainability

- **Substances from the earth's crust must not systematically increase in the ecosphere.**

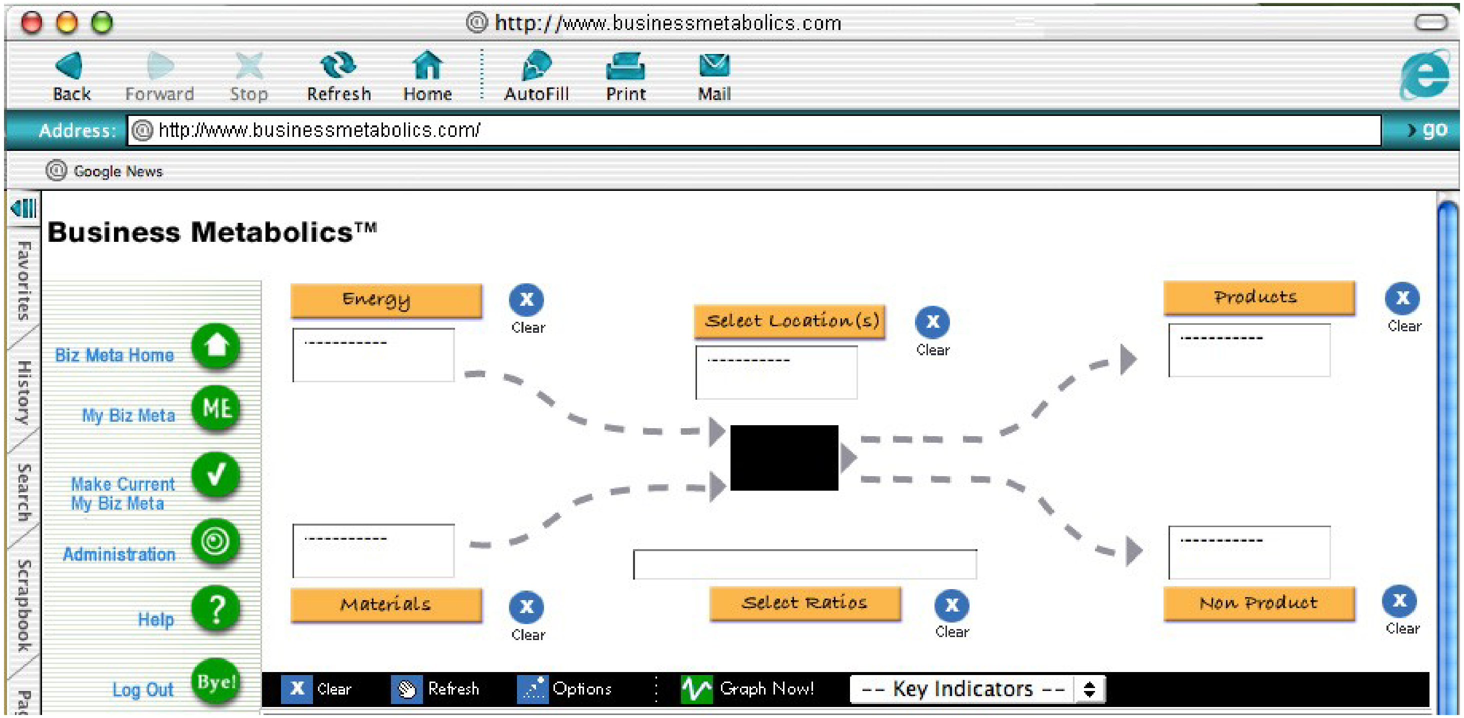
- **Substances produced by society must not systematically increase in the ecosphere.**

- **The physical basis for the productivity and diversity of Nature must not be systematically deteriorated.**

- **Resources must be used efficiently and fairly with respect to meeting human needs.**

– The Natural Step

Business Metabolics™



- Resource productivity trends
- Key ratios
- Throughput Pie™

- Internal+External Benchmarks
- Link “environmental” & business factors

The Challenge Ahead

“New industrial revolution”

- **Products, services and whole businesses that reduce, eliminate or reverse impact on the environment… profitably!**
- **Cars that clean the air**
- **Factories that clean the water**
- **Buildings—and cities—with “zero ecological footprint”**
- **Companies that make more money selling *less* “stuff”**
- **“Making the world work for 100% of humanity”**

Challenges: Industrial Ecology

- **Business issues**
  - Matching resource flows
  - Reliability of supplies
  - Contract design
- **Development issues**
  - Evolved vs purposive systems
  - Entrepreneur vs public authority initiated
- **Regulatory and legal issues**
  - Waste or resource - RCRA
  - Incentives / Disincentives: pollution, waste disposal, virgin materials
  - Technology standards -> peformance standards
  - High-leverage, non-lethal control variables
  - Zero emissions zoning

Challenges: High Tech

Issues

- Supply chain
- Ecological footprint
- Digital divide

Innovative business responses:

- HP+Noranda: Mining the “waste” stream
- HP: eInclusion
- Various: selling service
- Still waiting: the modular endless upgradeable PC

Challenges: Your customers

Innovative business responses:

- Cargill-Dow: crop-based polymer feedstocks
- DuPont: zero waste, chemical management systems
- Millennium Chemicals: new market in fuel cell production for its zirconia, use of efficient CHP
- ASG Transport: “petroleum is a strategic dead end”

The key strategic question:

“What business are we really in?

Getting From Here to There

Asking the right questions

Not "*Can* we?"
"*How* can we?"

It's all about design

Natural Logic, Inc.

Strategy. Systems. Software.

Helping companies and communities prosper by embedding the laws of nature at the heart of enterprise.

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